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# The Consumption of the Fungus-infected Wood by Termite, *Coptotermes formosanus* SHIRAKI\*

Haruo MATSUO\*\* and Koichi NISHIMOTO\*\*

**Abstract**—The pine wood blocks decayed by 7 brown rot fungi, the decayed and ether extracted blocks and the sound wood blocks were set on the nest of the termite, and the weight loss (%) of each test piece was calculated. The ratio of the weight loss (the decayed wood/the sound wood, the decayed and ether extracted wood/the sound wood, or the decayed wood/the decayed and ether extracted wood) were also calculated.

The higher the degree of decay on the test pieces was, the higher the weight loss of the decayed blocks by termites was, and in some pieces the weight loss reached near 100%. The wood consumption of the decayed and ether extracted blocks by termites mostly ranged 30% to 60%. In both the decayed blocks and the decayed and ether extracted blocks, the consumption of sapwood by termites was generally higher than that of heartwood. Judging from the ratio, both the decayed blocks and the decayed and ether extracted blocks were eaten more than the sound blocks. The higher the weight loss due to decay was, the higher the ratio of the weight loss of the decayed blocks to that of the sound wood was. The ratio of the weight loss of the decayed and ether extracted wood to that of the sound wood, for the most part, ranged from 1 to 3.

## Introduction

It has recently been a subject of increasing interest why termites like the decayed wood.

LUND investigated the influence of five species of fungi in agar culture on the life of paired replicates each of ten individuals of a species of *Reticulitermes*. Comparing the times required for the mortality of 100%, he observed that *Poria incrassata* was helpful for termites to live, but that *Lentinus lepideus* FR. was antagonistic. It was also observed that termites live longer with *Lenzites trabea* PERS. ex FR., *Polyporus versicolor* (L) FRIES and *Poria monticola* MURR. in comparison with the control.<sup>1)</sup>

KOVOOR compared the effect of two kinds of fungi on *Microcerotermes edentatus* using poplar wood, and he found that termites prefer decayed wood to sound wood.<sup>2)</sup>

ESENTER *et al.*, paying their attention to the fact that the runways of *Reticulitermes* spp. on tree tend to go straight to decaying wood, suggested that a gradient of sensitivity to attractant materials might help termites find its food supply.<sup>3)</sup> They found that the wood blocks invaded by *Lenzites trabea* PERS. ex FR., one of eight species of fungi isolated from rotting woods or from termites, attract termites. The attractant seems to contain a trail-following substance to mark the route leading to a source of food.

STUART found that a trail-following substance is produced by the sternal gland of worker termite.<sup>4)</sup> SMYTHE found that such substance was also extracted from the western white pine rotted by the fungus *Lenzites trabea* PERS. ex FR., and that the extract was approximately 20 times as much attractive as the extract from the termite itself.<sup>5)</sup>

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It is doubtful, however, if there is a correlation between the fact that termites are attracted to the decayed wood and the fact that they eat the same wood. Moreover it is still rather dubious whether the wood infected by some fungi other than *L. trabea* is attractive to termites.

In an attempt to make these matters clear, the authors examined the consumption by *Coptotermes formosanus* SHIRAKI of woods invaded by 7 species of brown rot fungi, woods invaded by the said fungi and subsequently extracted with ether, and sound woods. The trail-following substance in the decay wood can be extracted with ether, and moreover the other attractants and the repellents in the same wood also seem to be extracted with ether. In this experiment, it was examined whether wood consumption by termites was influenced by ether extraction or not.

We intend to report the termite sensibility to these ether extracts in the next paper.

### Materials and Methods

The small substrate blocks (20×20×5mm) made from *Pinus densiflora* SIEB. et ZUCC. were infected by 7 species of brown rot fungi following the soil block method. The 7 species of brown rot fungi as well as the other experimental conditions are shown in Table 1.

Table 1. Fungal species and decay conditions.

Decay condition	Fungus	Wood block	Decay term (days)
AS <sub>30</sub>	A: <i>Tyromyces palustris</i> (BERK. et CURT.) MURR.	S: sapwood	30
AS <sub>60</sub>		H: heartwood	60
AH <sub>30</sub>		H: heartwood	30
AH <sub>60</sub>			60
BS <sub>30</sub>	B: <i>Daedalea dickinsii</i> YASUDA	S: sapwood	30
BS <sub>60</sub>		H: heartwood	60
BH <sub>30</sub>		H: heartwood	30
BH <sub>60</sub>			60
CS <sub>30</sub>	C: <i>Lenzites trabea</i> PERS. ex FR.	S: sapwood	30
CS <sub>60</sub>		H: heartwood	60
CH <sub>30</sub>		H: heartwood	30
CH <sub>60</sub>			60
DS <sub>30</sub>	D: <i>Gloeophyllum saepiarium</i> (FR.) KARST.	S: sapwood	30
DS <sub>60</sub>		H: heartwood	60
DH <sub>30</sub>		H: heartwood	30
DH <sub>60</sub>			60
ES <sub>30</sub>	E: <i>Coniophora puteana</i> (SCHUM. ex FR.) KARST.	S: sapwood	30
ES <sub>60</sub>		H: heartwood	60
EH <sub>30</sub>		H: heartwood	30
EH <sub>60</sub>			60
FS <sub>30</sub>	F: <i>Serpula lacrymans</i> (WULF.) S. F. GRAY	S: sapwood	30
FS <sub>60</sub>		H: heartwood	60
FH <sub>30</sub>		H: heartwood	30
FH <sub>60</sub>			60
GS <sub>30</sub>	G: <i>Lentinus lepideus</i> FR.	S: sapwood	30
GS <sub>60</sub>		H: heartwood	60
GH <sub>30</sub>		H: heartwood	30
GH <sub>60</sub>			60

The test blocks, dried at 60°C, weighed and sterilized in vapor of propylene oxide for 3 hours, were set annularly on the mycelium in the bottle. These test blocks were decayed for 30 days (or 60 days), then washed and dried, and the weight loss (%) of the blocks was determined. The incubator temperature was 28°C with the exception of the case of *Serpula lacrymans* (WULF) S. F. GRAY where the incubator temperature was 20°C.

**Test 1**—The termite attack to the decayed wood (compared with the sound wood)—

Five blocks decayed in the same decay condition and 5 sound blocks were placed on the yard of termite rearing bath alternately in a row. These test blocks were taken off from the yard after 4 to 6 days (the more speedily termites made the tunnel on the blocks, the shorter the test term was), washed with water, dried at 60°C and weighed. In many cases, this test was performed in 8 rows at a time, and included all the 28 groups of decayed blocks. The weight loss (%) caused by termites and the ratio-I (weight loss of the decayed wood to that of the sound wood) were calculated.

**Test 2**—Termite attack to the decayed and ether extracted wood (compared with the sound wood)—

Twenty five blocks decayed in the same condition were gathered and extracted with ether in a Soxhlet's extractor for 15 hrs. Five these extracted blocks and 5 sound blocks were tested as in Test 1. The weight loss (%) caused by termites and the ratio-II (weight loss of the decayed and ether extracted wood to that of the sound wood) were calculated.

**Test 3**—The termite attack to the decayed wood (compared with the decayed and ether extracted wood)—

Five decayed blocks and 5 decayed and ether extracted blocks, both treated in the same decay condition, were tested as in Test 1. The weight loss (%) caused by termites and the ratio-III (weight loss of the decayed wood to that of the decayed and ether extracted wood) were calculated.

**Test 4**—The relation between the degree of decay and the termite attack (especially concerning fungi E and F)—

The blocks of sapwood or heartwood invaded by the fungus E or F were classified to the groups of which weight losses due to decay were 1%, 10%, 20%, 30%, 40% and 50% respectively. Five blocks decayed in the same group and 5 sound blocks were tested as in Test 1. The weight loss (%) and the ratio-IV (weight loss of the decayed wood to that of the sound wood) were calculated.

## Results and Discussion

The authors calculated the average weight loss (%) of 25 decayed blocks picked up at random from 100 decayed blocks in the same decay condition. As shown in Table 2, the wood blocks invaded by the fungus E or F were decayed sufficiently, so that they often could not keep the original dimension. Weight loss (%) due to decay was above 20% in the sapwood invaded by the fungus F, but was not so high with the other fungi. Although the mycelium of the fungus A or B covered the surface of the test blocks, the highest weight loss (%) was merely about 3%. This suggests that the size of the test block may not have been appropriate to decay or that the wood decomposing ability of the fungi may have been decreased because of cultivation from generation to generation in the pure culture on malt agar.

It is generally said that sapwood is decayed more easily than heartwood in *Pinus densiflora*. In the present experiment, however, there was an exception ( $ES_{60}$ =ca. 2%,  $CH_{60}$ =ca. 10%). This should be thought as an extraordinary example. The longer the test term was, the higher the weight loss (%) was. However, there is an exception in  $ES_{60}$ .

Table 3 and Fig. 1 show that the decayed woods were more eaten than the sound woods (The ratio-I was more than 1). The ratio-I of  $EH_{60}$  was about 25, those of  $BH_{60}$ ,  $ES_{60}$ ,  $EH_{30}$ ,

Table 2. Decay conditions and weight losses of wood blocks.

Decay condition	Weight loss (%)*
AS <sub>30</sub>	1.38
AS <sub>60</sub>	3.06
AH <sub>30</sub>	0.19
AH <sub>60</sub>	0.29
BS <sub>30</sub>	0.35
BS <sub>60</sub>	2.78
BH <sub>30</sub>	0.19
BH <sub>60</sub>	2.22
CS <sub>30</sub>	3.99
CS <sub>60</sub>	4.62
CH <sub>30</sub>	0.49
CH <sub>60</sub>	9.96
DS <sub>30</sub>	0.59
DS <sub>60</sub>	0.63
DH <sub>30</sub>	0.24
DH <sub>60</sub>	0.19
ES <sub>30</sub>	12.91
ES <sub>60</sub>	1.88
EH <sub>30</sub>	12.45
EH <sub>60</sub>	22.91
FS <sub>30</sub>	22.35
FS <sub>60</sub>	36.45
FH <sub>30</sub>	2.59
FH <sub>60</sub>	12.11
GS <sub>30</sub>	0.45
GS <sub>60</sub>	0.86
GH <sub>30</sub>	0.09
GH <sub>60</sub>	0.06

\* The average of 25 test pieces picked up at random from 100 test pieces in the same decay condition.

FS<sub>30</sub> and FS<sub>60</sub> were 5 to 10, and those of CS<sub>30</sub>, CH<sub>60</sub> and FH<sub>60</sub> were near 5. The weight loss (%) due to decay of these blocks was relatively high. Irrespective as to whether the test block is of sapwood or heartwood, Fig. 1 shows, as a general rule, that the higher the degree of decay on the test blocks is, the higher the wood consumption by termites is. The ratio-I of the test pieces decayed by fungus D was low (ca. 2), because the sound woods were abnormally eaten very much. This shows that weight loss of the sound blocks caused by termites is influenced to a certain extent by the number of the rows of the test blocks (experimented in 4 rows in the fungus D). The weight loss (%) of the decayed wood by termites was generally higher in sapwood than in heartwood except the fungus B. The weight loss (%) of the wood decayed by the fungus C, D, E or F caused by termites was sometimes more than 50%. It seems that the termite attack is promoted by decaying of the wood.

Table 4 and Fig. 2 show that the decayed and ether extracted woods except DH<sub>30</sub> and DH<sub>60</sub> were more eaten than the sound wood (The ratio-II was more than 1). The ratio-II, however, was not so high but the maximum (6.90) in AH<sub>60</sub>, and in most cases 1 to 3. The ratio-II of DH<sub>30</sub> and DH<sub>60</sub> were less than 1, because the sound woods were eaten very much (experimented in 4 rows in the fungus D).

In AH<sub>30</sub> or AH<sub>60</sub>, the ratio-II of the decayed and ether extracted woods was much higher than that of the non extracted wood, because the sound wood was not eaten as usual. The weight loss (%) of the decayed and ether extracted wood caused by termites was generally higher in sapwood than in heartwood (except the decayed and extracted wood E). The weight

Table 3. Termite attack to the decayed wood and the sound wood.

Decay condition	Weight loss due to decay (%)*	a	b	The ratio-I (a/b)
		Weight loss of the decayed wood by termites (%)*	Weight loss of the sound wood by termites (%)*	
AS <sub>30</sub>	1.50	22.88	8.96	2.55
AS <sub>60</sub>	2.69	16.66	5.94	2.80
AH <sub>30</sub>	0.10	8.76	5.96	1.47
AH <sub>60</sub>	0.35	13.06	3.33	3.92
BS <sub>30</sub>	0.42	13.03	6.71	1.94
BS <sub>60</sub>	3.35	13.43	6.42	2.09
BH <sub>30</sub>	0.25	8.45	4.93	1.71
BH <sub>60</sub>	4.13	29.77	4.80	6.20
CS <sub>30</sub>	14.71	60.64	12.21	4.97
CS <sub>60</sub>	3.86	35.50	12.25	2.90
CH <sub>30</sub>	0.18	8.02	6.49	1.24
CH <sub>60</sub>	7.27	24.53	5.02	4.89
DS <sub>30</sub>	0.59	55.62	28.07	1.98
DS <sub>60</sub>	1.92	53.40	26.38	2.02
DH <sub>30</sub>	0.61	16.28	6.85	2.38
DH <sub>60</sub>	0.37	40.45	21.76	1.86
ES <sub>30</sub>	2.67	28.16	10.64	2.65
ES <sub>60</sub>	5.99	85.21	9.05	9.42
EH <sub>30</sub>	14.76	12.75	1.92	6.64
EH <sub>60</sub>	41.98	88.28	3.49	25.30
FS <sub>30</sub>	18.47	80.31	8.31	9.64
FS <sub>60</sub>	36.62	89.30	10.78	8.28
FH <sub>30</sub>	1.01	13.17	7.68	1.71
FH <sub>60</sub>	12.56	34.79	7.27	4.79
GS <sub>30</sub>	1.34	27.13	10.18	2.67
GS <sub>60</sub>	2.23	40.37	8.77	4.60
GH <sub>30</sub>	0.06	12.36	8.17	1.51
GH <sub>60</sub>	0.50	13.19	11.69	1.13

\* The average of 5 test pieces.

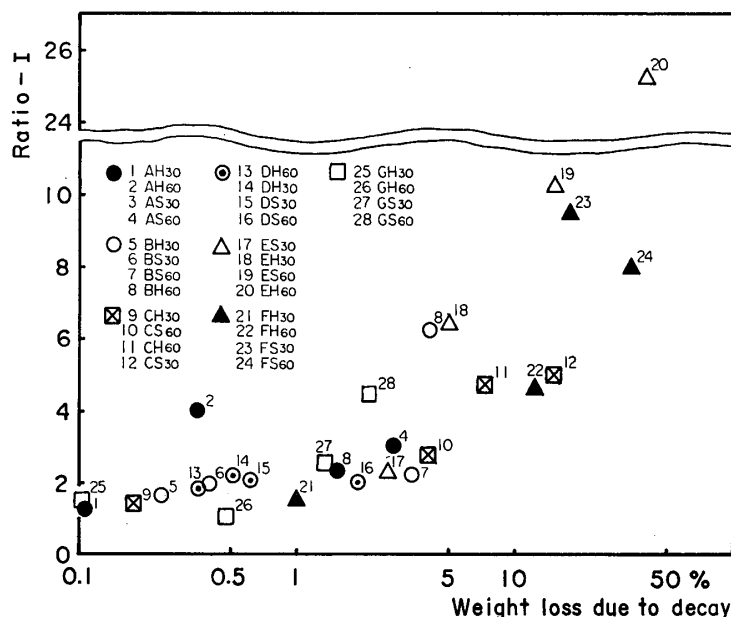


Fig. 1. Termite attack to the decayed wood and the sound wood.

loss (%) of the decayed and ether extracted wood caused by termites in most cases ranged from 30% to 60%. This shows that termite attack would be influenced considerably by the ether extraction.

Table 4. Termite attack to the decayed and ether extracted wood and the sound wood.

Decay condition	Weight loss due to decay (%) <sup>*</sup>	a	b	The ratio-II (a/b)
		Weight loss of the decayed and extracted wood by termites (%) <sup>*</sup>	Weight loss of the sound wood by termites (%) <sup>*</sup>	
AS <sub>30</sub>	1.38	56.96	21.45	2.65
AS <sub>60</sub>	3.06	56.25	19.35	2.91
AH <sub>30</sub>	0.19	44.67	7.16	6.24
AH <sub>60</sub>	0.29	51.55	7.47	6.90
BS <sub>30</sub>	0.35	43.68	15.52	2.81
BS <sub>60</sub>	2.78	44.38	17.67	2.59
BH <sub>30</sub>	0.19	30.37	14.31	2.12
BH <sub>60</sub>	2.22	34.82	12.20	2.85
CS <sub>30</sub>	3.99	65.54	48.68	1.35
CS <sub>60</sub>	4.62	63.34	46.75	1.35
CH <sub>30</sub>	0.49	33.94	28.32	1.20
CH <sub>60</sub>	9.96	28.21	22.75	1.24
DS <sub>30</sub>	0.59	61.53	57.89	1.06
DS <sub>60</sub>	—	—	—	—
DH <sub>30</sub>	0.24	42.27	44.59	0.95
DH <sub>60</sub>	0.19	33.93	36.40	0.93
ES <sub>30</sub>	12.91	92.95	29.06	3.20
ES <sub>60</sub>	1.88	34.04	20.81	1.64
EH <sub>30</sub>	12.45	26.13	16.37	1.60
EH <sub>60</sub>	22.91	44.87	8.97	5.00
FS <sub>30</sub>	22.35	98.77	18.69	5.28
FS <sub>60</sub>	36.45	91.44	21.67	4.22
FH <sub>30</sub>	2.59	32.03	20.45	1.57
FH <sub>60</sub>	12.11	46.72	11.23	4.16
GS <sub>30</sub>	0.45	42.69	34.29	1.24
GS <sub>60</sub>	0.86	46.38	29.84	1.55
GH <sub>30</sub>	0.09	29.95	4.44	6.75
GH <sub>60</sub>	0.06	37.37	26.73	1.40

\* The average of 5 test pieces.

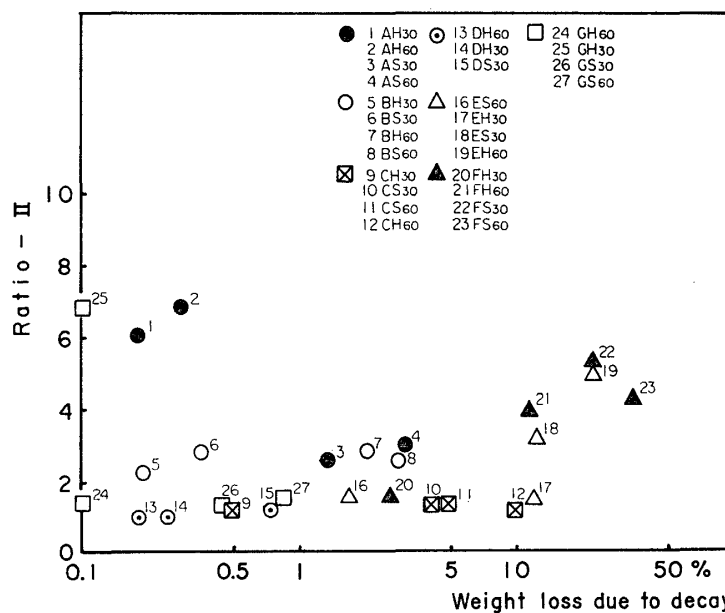


Fig. 2. Termite attack to the decayed and ether extracted wood and the sound wood.

Table 5 shows that most of the ratio-III values were about 1, therefore it may be considered that the degree of the attack to the decayed wood by termites was nearly equal to that of the attack to the decayed and ether extracted wood. The ratio-III in EH<sub>30</sub> was extraordinarily low (0.13).

Table 5. Termite attack to the decayed wood and the decayed and ether extracted wood.

Decay condition	Weight loss due to decay (%)*	a	b	The ratio-III (a/b)
		Weight loss of the decayed wood by termites (%)*	Weight loss of the decayed and extracted wood by termites (%)*	
AS <sub>30</sub>	1.38	54.62	59.68	0.92
AH <sub>30</sub>	0.19	48.14	43.29	1.11
BS <sub>30</sub>	0.35	60.19	61.22	0.98
BH <sub>30</sub>	0.19	34.81	33.26	1.05
CS <sub>30</sub>	3.99	65.11	73.37	0.89
CH <sub>30</sub>	0.49	61.36	28.67	2.14
DS <sub>30</sub>	0.59	77.00	70.41	1.09
DH <sub>30</sub>	0.24	26.53	42.14	0.63
ES <sub>30</sub>	12.91	82.02	89.46	0.92
EH <sub>30</sub>	12.45	3.98	29.62	0.13
FS <sub>30</sub>	22.35	100.00	76.67	1.30
FH <sub>30</sub>	2.59	30.37	38.00	0.80
GS <sub>30</sub>	0.45	57.01	52.12	1.09
GH <sub>30</sub>	0.09	14.56	28.36	0.51

\* The average of 5 test pieces.

Table 6. Relation between termite attack and degree of decay (especially concerning fungi E and F).

Decay condition	Weight loss due to decay (%)*	a	b	The ratio-IV (a/b)
		Weight loss of the decayed wood by termites (%)*	Weight loss of the sound wood by termites (%)*	
ES 1%	2.67	28.16	10.64	2.65
ES 10%	12.58	89.27	8.89	10.04
ES 20%	15.99	85.21	9.05	9.42
ES 30%	30.28	98.66	8.81	11.20
EH 1%	4.76	12.75	1.92	6.64
EH 10%	13.35	37.17	4.30	8.64
EH 20%	—	—	—	—
EH 30%	31.25	53.80	3.86	13.90
EH 40%	41.98	88.28	3.49	25.30
EH 50%	49.46	100.00	19.50	5.13
FS 1%	—	—	—	—
FS 10%	12.58	70.06	5.71	12.27
FS 20%	18.47	80.31	8.31	9.64
FS 30%	30.39	99.83	8.27	12.07
FS 40%	36.62	89.30	10.78	8.78
FS 50%	52.61	96.10	23.37	4.11
FH 1%	1.01	13.17	7.68	1.71
FH 10%	12.56	34.79	7.27	4.79
FH 20%	20.38	40.86	10.65	3.84
FH 30%	29.17	80.17	3.27	24.52
FH 40%	38.43	52.80	9.80	5.39
FH 50%	51.67	98.10	9.22	10.64

\* The average of 5 test pieces.

It is because the decayed wood EH<sub>30</sub> was not in the good conditions and the wood consumption by termites was very low (3.98%). The weight loss (%) of the decayed wood as well as the decayed and ether extracted wood by termites were higher in sapwood than in heartwood.

Fig. 3 shows that the higher the degree of decay on the test pieces is, the higher the weight loss (%) of the decayed blocks caused by termites is. When the weight loss (%) due to decay was more than 10% in the decayed wood ES, more than 40% in the decayed wood EH, more than 20% in the decayed wood FS and more than 30% in the decayed wood FH, the weight loss (%) due to termites was more than 80%. It is clear that weight loss (%) of the decayed wood E or F caused by termites was higher in sapwood than in heartwood. Table 6 shows that the ratio-IV fell sharply at 40% and/or 50% of the weight loss (%) due to decay because



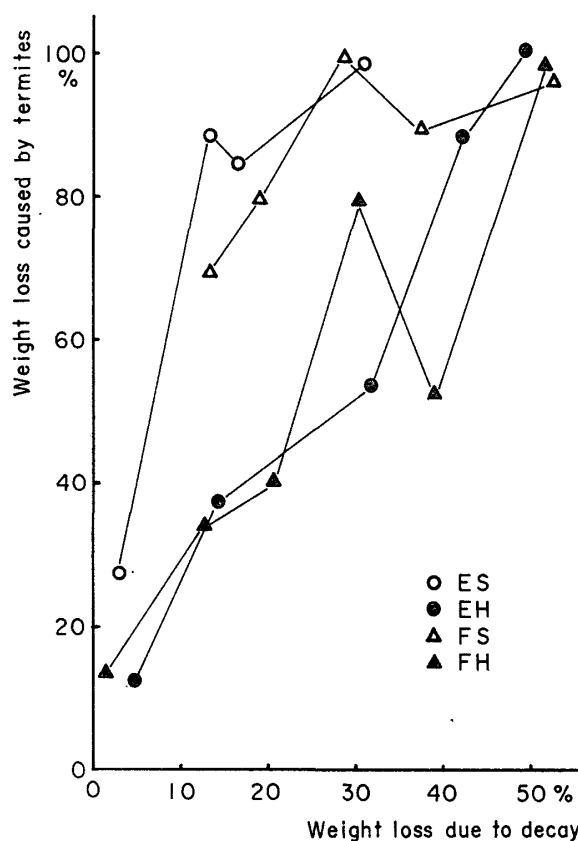


Fig. 3. Relation between termite attack and degree of decay (especially concerning fungi E and F).

the weight loss (%) of the sound wood caused by termites was very high. Termites ate the decayed blocks almost wholly and was obliged to eat the sound wood very much. Therefore, the test term of the termite attack should have been shortened a little more.

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